PHENOLOGY OF THE AUSTRALIAN SOLITARY BEE SPECIES *LEIOPROCTUS PLUMOSUS* (SMITH) (HYMENOPTERA: COLLETIDAE)

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Abstract

A nesting aggregation of the bee species *Leioproctus (Leioproctus) plumosus* (Smith, 1853) in a suburban garden was observed for a period of seven years. Between one and three generations per year were observed and estimates obtained for the development time and lifespan of adults. The emerging bees were accompanied, at this site, by the parasitic ichneumonid wasp *Labium pettitorium* (Erichson, 1842).

Introduction

Surprisingly little is known about the life cycles of Australian bees in the family Colletidae, which contains 53% of named Australian species (AFD 2013). Several species in the family Apidae (Cardale 1968a, b, Steen and Schwarz 2000, Schwarz *et al.* 2007 and references therein, Halcroft *et al.* 2013) and one halictine species (Kukuk *et al.* 2005 and references therein), have received significant study but observations of colletids have been restricted to indirect inferences concerning the number of generations per year.

Observation of adult activity at times separated by more than 8 weeks has frequently been taken as an indication of two or more generations *per annum* (*e.g.* Houston 1971, 1975, 1987), based on the expectation that solitary bees have an active lifespan of only a few weeks (Michener 2007). Exceptions, like the queens of highly social species or species that overwinter as adults, are uncommon, although the colletid species *Amphylaeus morosus* is reported to live for up to a year (Spessa *et al.* 2000). The observations need to be made at the same or similar locations as the activity periods for univoltine species at different places may be widely out of phase (Houston 1991).

On this basis, six Australasian *Leioproctus* species are believed to be univoltine and six bivoltine or multivoltine (Rayment 1935, 1950, Donovan 1980, Houston 1990, Houston and Maynard 2012, Maynard 2013), but no detailed phenology of an Australian *Leioproctus* species has been reported.

Leioproctus plumosus (Smith) (Fig. 1) is widely distributed throughout Australia but predominantly in coastal regions in the southern half of the continent (Fig. 2). While Museum collection data (Fig. 3; ALA 2013) indicate that *L. plumosus* is active over an extended period, it is unclear whether this is an indication of multivoltinism or just the result of combining data from a range of environments.

A nesting aggregation of *L. plumosus* in a domestic garden in Ulladulla, a coastal site *ca* 170 km south of Sydney, NSW, provided an opportunity to examine the emergence of adult bees over a period of several years.

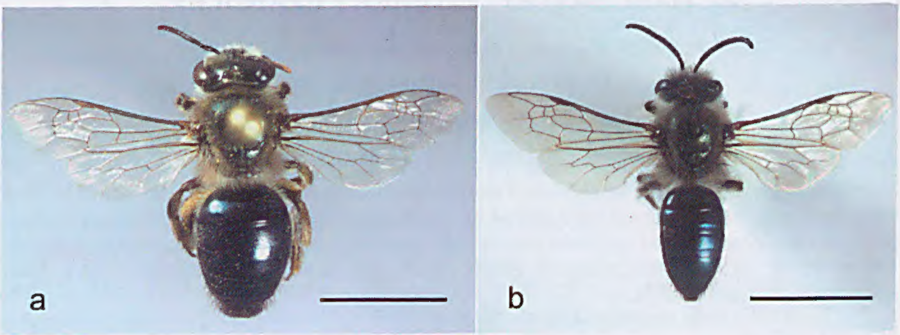


Fig. 1. *Leioproctus plumosus*: (a) female (b) male. Scale bars = 5 mm.

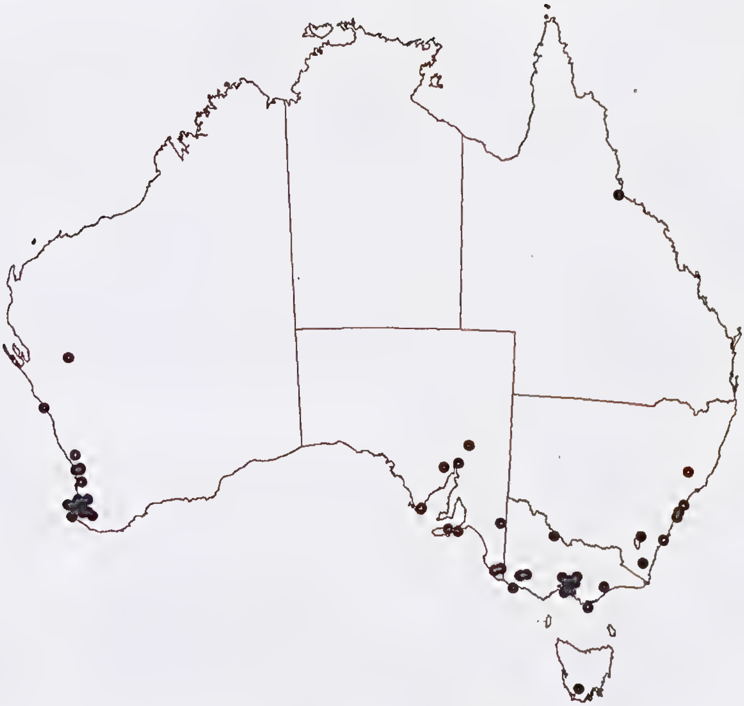
Methods

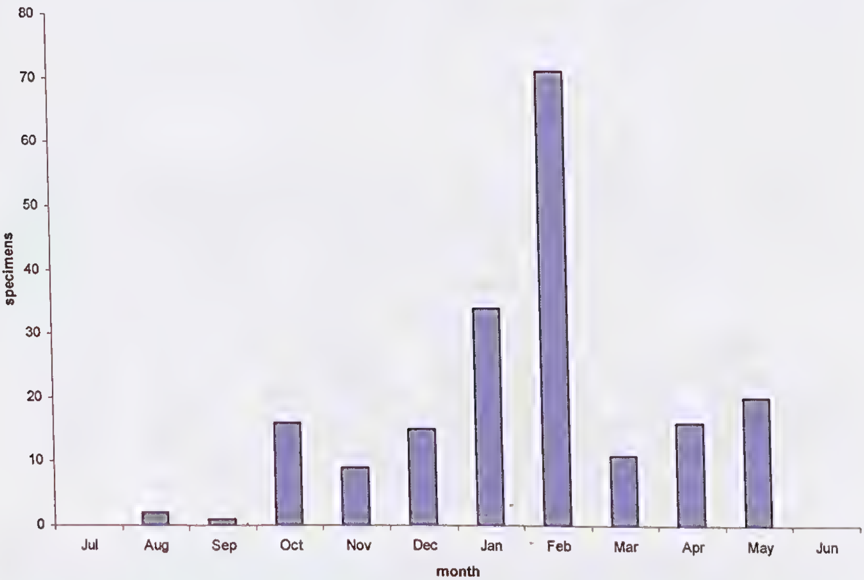
The activity of adult bees was monitored by visual observation of males flying near the ground and above vegetation in the vicinity of the nesting site and females returning to nesting tunnels in the ground. Observations were made over eight seasons from October 2005 to April 2013. No attempt was made to quantify the number of individuals. One male and three female bees, plus ten female ichneumonid wasps, were collected for identification. These specimens have been lodged in the Australian Museum.

Leioproctus plumosus specimens were identified using the male genitalia and hidden sterna (Maynard 2013). *Labium pettitorium* (Erichson, 1842) (redescribed by Turner and Waterston 1920) was identified by the coarse punctures on the scutum, the strong projections from the propodeum, overall colour and the number of flagellar segments. *Labium inflexum* (Morley, 1914), which was transferred to the genus *Labium* by Townes *et al.* 1961, is one of the few yellow *Labium* species and was identified by the colour pattern, including infuscation of the wing tips (Morley 1914). Records from the Australian Bureau of Meteorology automatic weather station number 69138 (Station name: Ulladulla AWS), were obtained from the Bureau's internet site (BOM 2013). The station is located 550 m from the nest site.

Results

Each year the bees emerged in late October or early November and disappeared before the end of December (except in 2012). In six of the eight years, a second emergence was seen between the middle of January and the middle of February, although there was some variation in the exact starting date. In three of the years, a third emergence was seen in autumn (Table 1, Fig. 4), although on both occasions the number of bees seen was small.





Figs 2-3. (2) Location and (3) month collected for *Leioproctus plumosus* specimens recorded in Atlas of Living Australia.

Table 1. Emergence dates and length of active periods for *Leioproctus plumosus*.

year	emerged	active period (days)	emerged	active period (days)	emerged	active period (days)
2005-6	late Oct	?	1 Jan	37	8 Mar	37
2006-7	14 Oct	48				
2007-8	31 Oct	44	25 Jan	31	4 Apr	32
2008-9	30 Oct	60	3 Feb	49		
2009-10	26 Oct	61	19 Jan	33	2 Apr	17
2010-11	12 Nov	38				
2011-12	5 Nov	36	25 Jan	?		
2012-13	4 Nov	65	6 Feb	33		

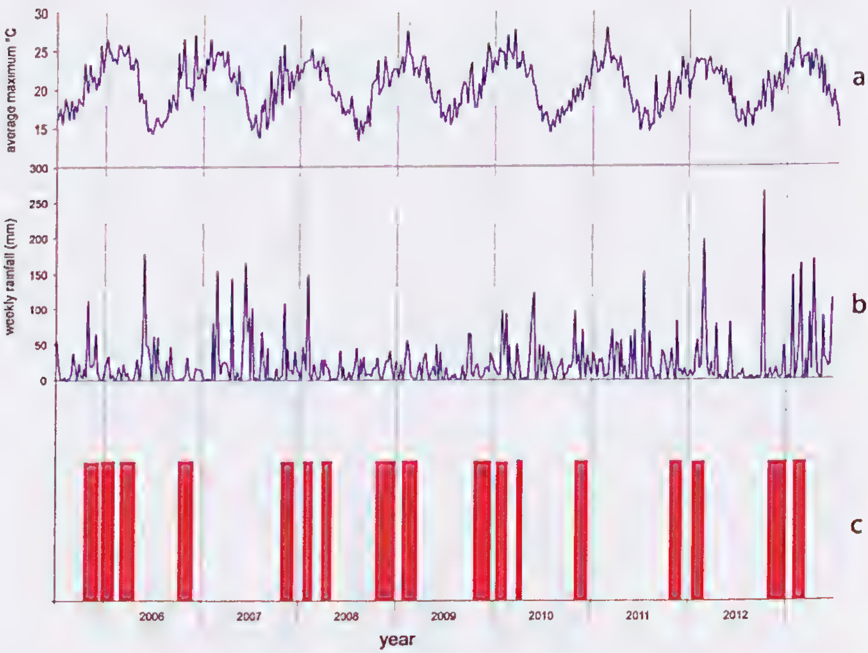


Fig. 4. Weather parameters and nesting activity of *Leioproctus plumosus*: (a) weekly average maximum temperature; (b) weekly rainfall at Ulladulla AWS; (c) observed periods of activity at nesting site. Vertical scale indicates presence or absence of bees.

The mean length of the spring and summer activity periods was 45 days (s.d. 11 days), while the intervals between activity periods were estimated as differences between either the mid-points of activity or the dates of first emergence. The former gave an average of 75 days (s.d. 8 days), while first emergences were separated by an average of 83 days (s.d. 9 days).

Ichneumonid wasps, identified as *Labium pettitorium* (Erichson) (Fig. 5a), were frequently observed patrolling the nesting site. The wasps were first noticed in all years, but their number relative to that of the bees was noticeably high in 2010/11 and noticeably small in 2012/13. A different wasp species, *Labium inflexum* (Morley) (Fig. 5b), was found in another *L. plumosus* colony in a garden in the Sydney suburb of Lilyfield in October 2000, demonstrating that *L. plumosus* may be parasitised by more than one *Labium* species.

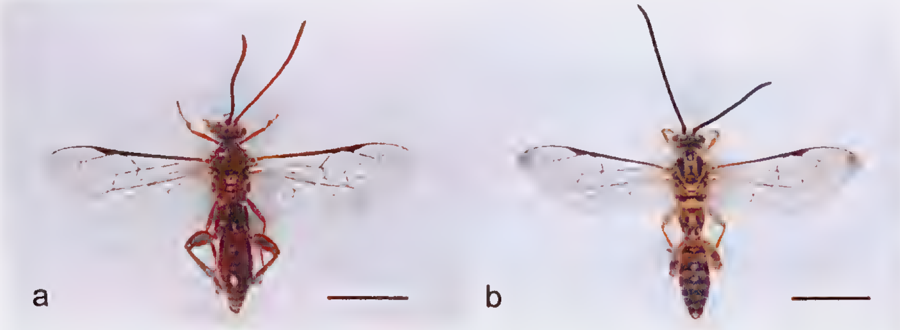


Fig. 5. *Labium* species: (a) *L. pettitorium* female; (b) *L. inflexum* female. Scale bars = 5 mm.

Discussion

The observations demonstrate that *Leioproctus plumosus* is unambiguously multivoltine and individuals have short lifetimes like many other solitary species (Michener 2007). Consequently, the extended period of activity shown in Fig. 3 can be explained by the blurring of gaps between generations by small variations in emergence times at different sites.

No attempt was made to estimate the lifespan of the bees by marking individuals, but the length of the active periods provides a rough estimate. Given that most female hymenopterans probably mate only once and consequently males emerge slightly earlier than females (Alcock *et al.* 1978), we estimate that individual bees of this species live for between 30 and 50 days.

Adults emerging in the second period of activity are probably offspring of bees that emerged in the first period rather than of bees active a year earlier. Consistent with this interpretation are the observations that (i) summer and autumn hatchings occurred even when there was only a spring hatching in the previous year and (ii) no autumn emergence was seen in the absence of a summer generation in the same year (Fig. 4).

The time intervals between activity periods ranged from 65 to 90 days, which is comparable with the development times reported for other species. The minimum time for adult development of the ground-nesting species *Amegilla pulchra* was estimated to be 42-65 days (Cardale 1968a), similar to the 55 days found for *Austroplebeia australis* (Halcroft *et al.* 2013). Although *A. australis* is eusocial, its larvae develop within sealed cells. For other species, only the time between pupation and eclosion of the adults has been observed. For *Lithurgus atratiformis* the length of this pupal stadium was 22 days (Houston 1971), for *Amegilla paracalva* 22 days (Houston 1991) and for *Stenotritus greavesi* 51 days (Houston and Thorp 1984). Hence the intervals between periods of activity exhibited by *L. plumosus* are not shorter than those expected between generations.

The occasional failure of the summer and/or autumn generations does not seem to be correlated with either rainfall or maximum temperature (Fig. 4). In fact, the bees were particularly numerous in the spring of 2012 and summer of 2013 despite particularly heavy rain shortly before emergence. Three weeks before the spring emergence 233 mm of rain fell in 24 hours and one week before the summer emergence there was a fall of 105 mm.

No obvious correlation was observed between bee emergence and flowers in bloom at the time. *Leioproctus plumosus* is known to visit a range of flowers from at least four plant families (Maynard 2013) and the area within a radius of 400 m around the nesting site consisted entirely of suburban gardens in which exotic species were predominant. Furthermore, the bees are active over a period longer than the flowering time of most plants and must therefore exploit several flower species. Hence it is unlikely that the emergence times have become synchronised with the blooming of any particular flower.

A more likely explanation for the variations is that the number of bees is affected by parasitism, as has been suggested for other species (Dolphin 1979). Although the number of *L. pettitorium* wasps was not measured, their number was noticeably high in 2010/11, when the summer and autumn generations failed to appear and noticeably low in 2012/13, when bee numbers were greater than average.

Conclusion

Relatively little is known about the life history of Australian bees, yet simple observations of a nesting site over an extended period of time could provide useful information not available from accumulated museum records. Collections usually contain a small number of specimens from each site and the data are, therefore, averaged over a range of sites and times, leading to a blurring of information. Citizen scientists could make valuable contributions (Danielson *et al.* 2003) to the understanding of our bee fauna.

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